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(54) **EXPOSURE DEVICE AND IMAGE FORMATION APPARATUS HAVING THERMALLY-CONDUCTIVE SEALANT**

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G02B 7/02	(2006.01)
G02B 3/06	(2006.01)
G02B 27/62	(2006.01)
G02B 19/00	(2006.01)

(52) **U.S. Cl.**

CPC ***G03G 15/0409*** (2013.01); ***G02B 3/06*** (2013.01); ***G02B 7/025*** (2013.01); ***G02B 27/62*** (2013.01); *G02B 19/0066* (2013.01); *Y10T 29/49828* (2015.01)

(58) **Field of Classification Search**

CPC .. G03G 15/409; F21Y 2103/003; B41J 2/45; H05K 3/281; G02B 3/06; G02B 7/025; G02B 27/62; G02B 19/0066; Y10T 29/49828

USPC 399/4

See application file for complete search history.

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(57) **ABSTRACT**

An exposure device includes: a substrate having a first and second surface opposed to each other, wherein a light-emitting element array is mounted on the first surface; a protective sheet covering the second surface while exposing a part of the second surface in the vicinity of an edge of the substrate to define an exposed part of the second surface; a holder that supports a condenser lens array and that supports the substrate, with a gap formed between the holder and the exposed part of the substrate, to position the substrate such that light emitted from the light-emitting element array is condensed on a predetermined irradiation location through the condenser lens array; and a thermally-conductive sealant that covers the exposed part of the second surface of the substrate and seals the gap.

10 Claims, 7 Drawing Sheets

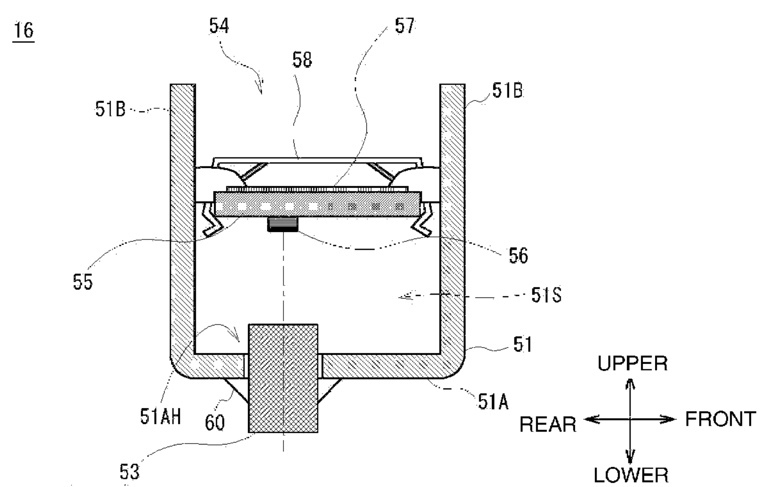
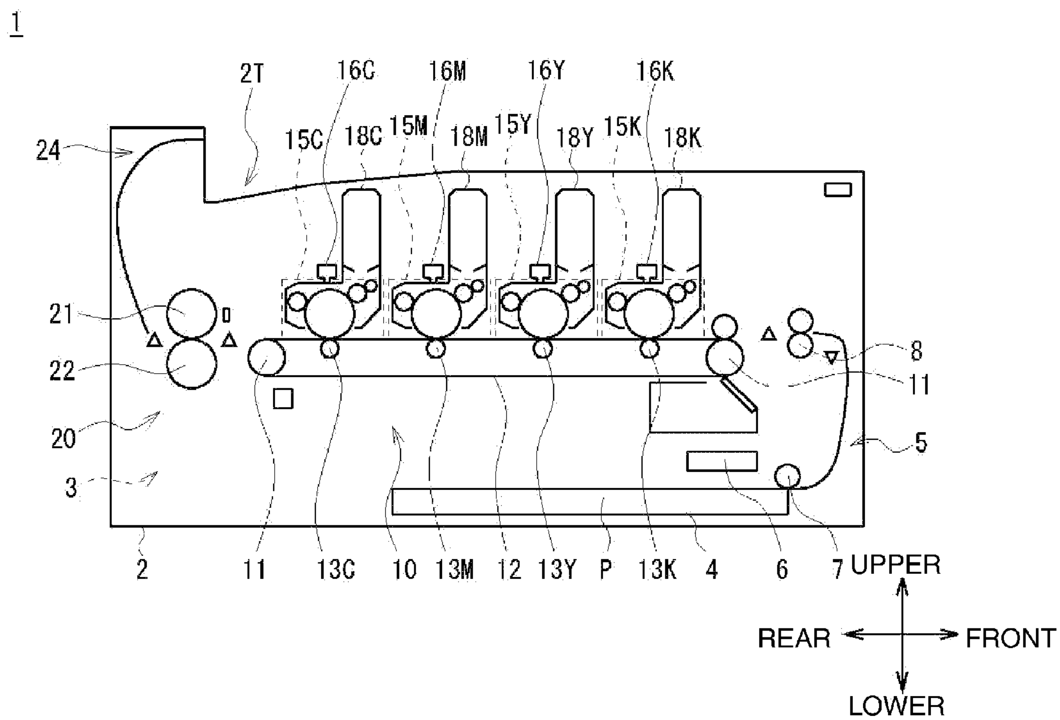


Fig. 1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16M
16Y
16K
24
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18C
15M
18M
15Y
18Y
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22
20
3
8
11
5
2
11
13C
10
13M
12
13Y
P
13K
4
6
7
UPPER
REAR
FRONT
LOWER

Fig. 2

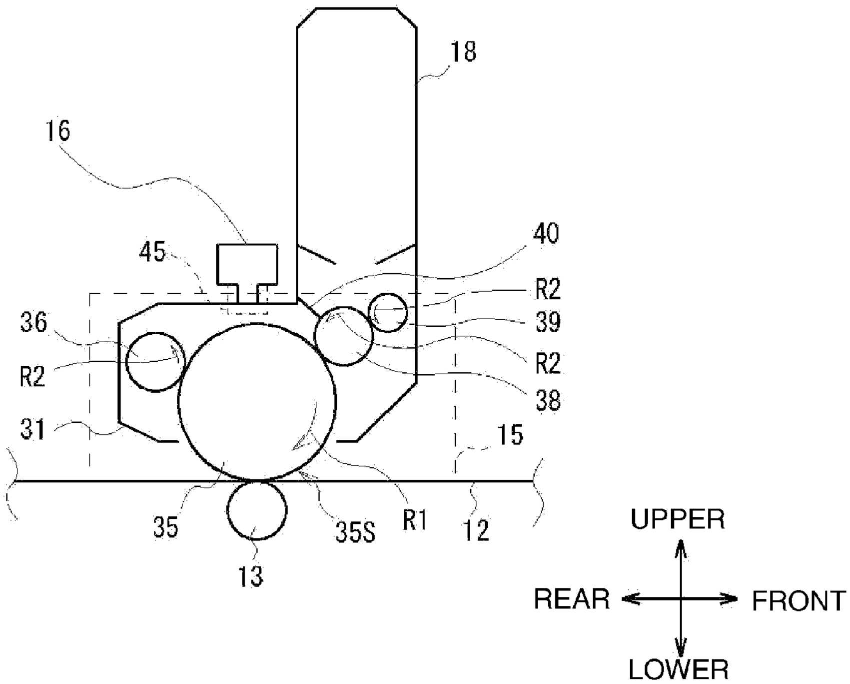
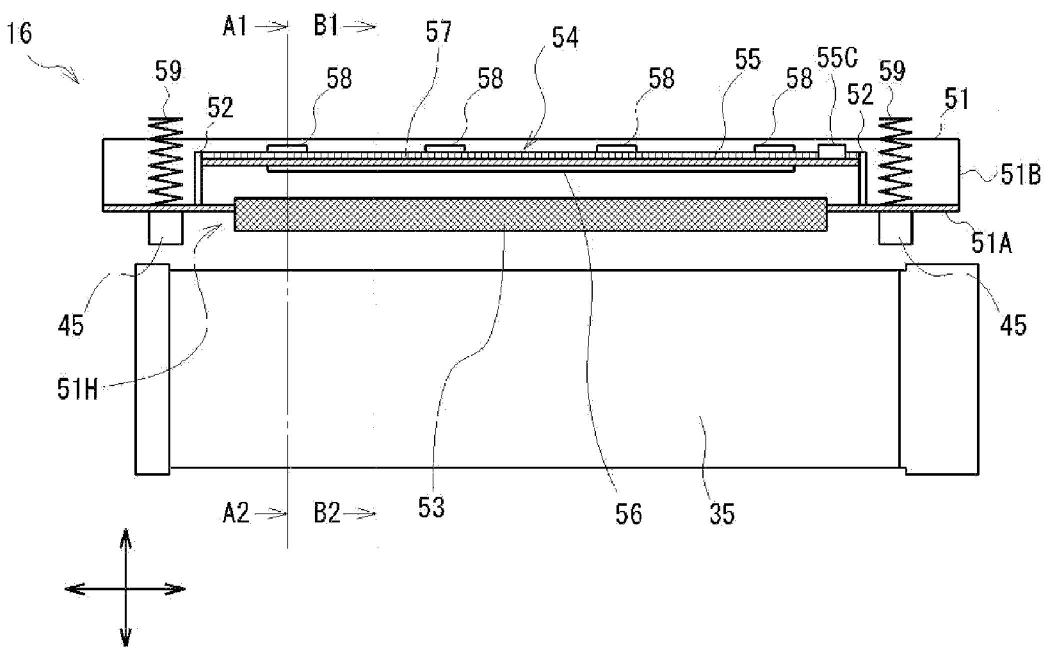

18
16
45
40
R2
39
36
R2
R2
38
31
15
35
35S
R1
12
13
UPPER
REAR
FRONT
LOWER

Fig. 3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B1
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58
58
55
58
55C
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51B
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45
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51H
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B2
53
56
35

Fig. 4

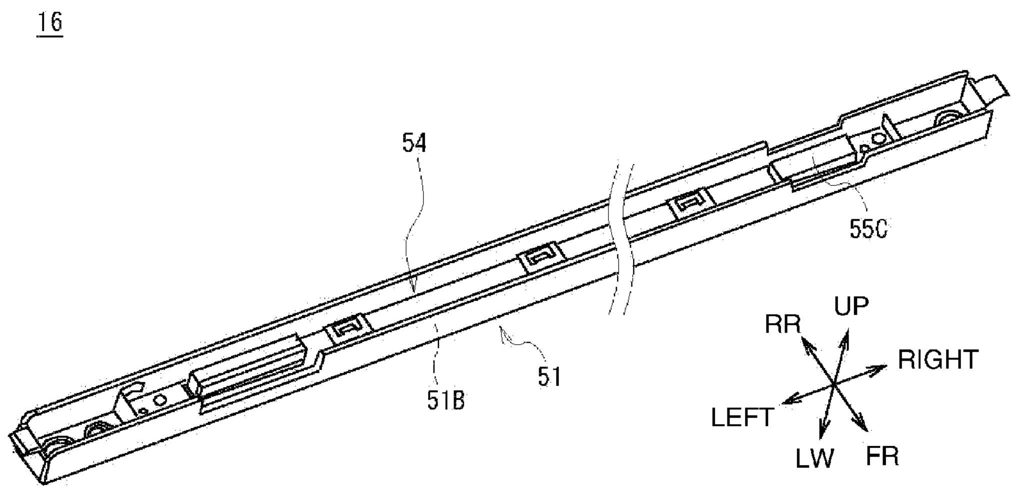


Fig. 5

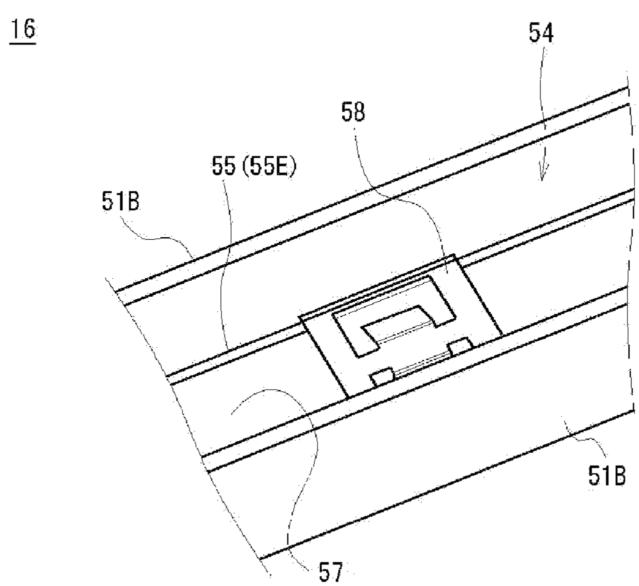


Fig. 6A

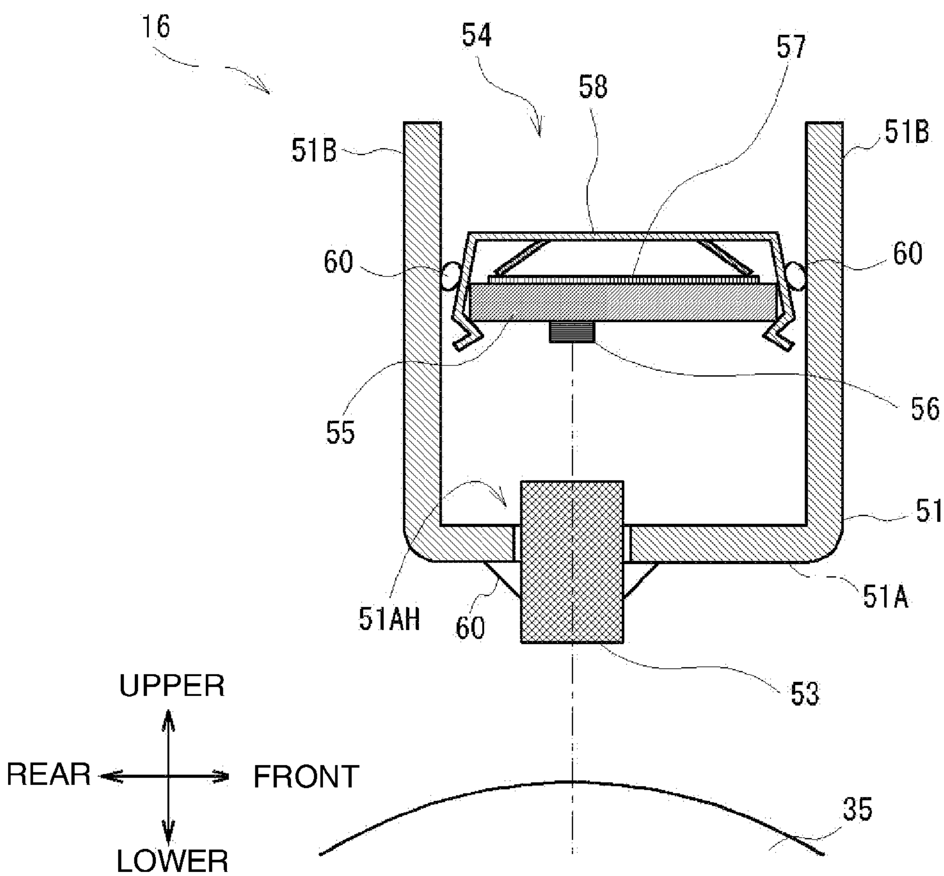

16
54
58
57
51B
51B
60
60
55
56
51
51AH
60
51A
53
UPPER
REAR
FRONT
LOWER
35

Fig. 6B

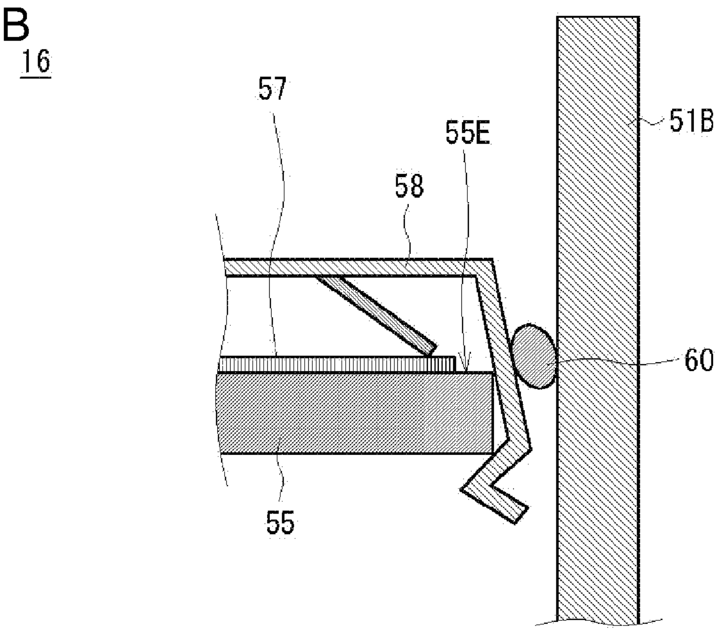
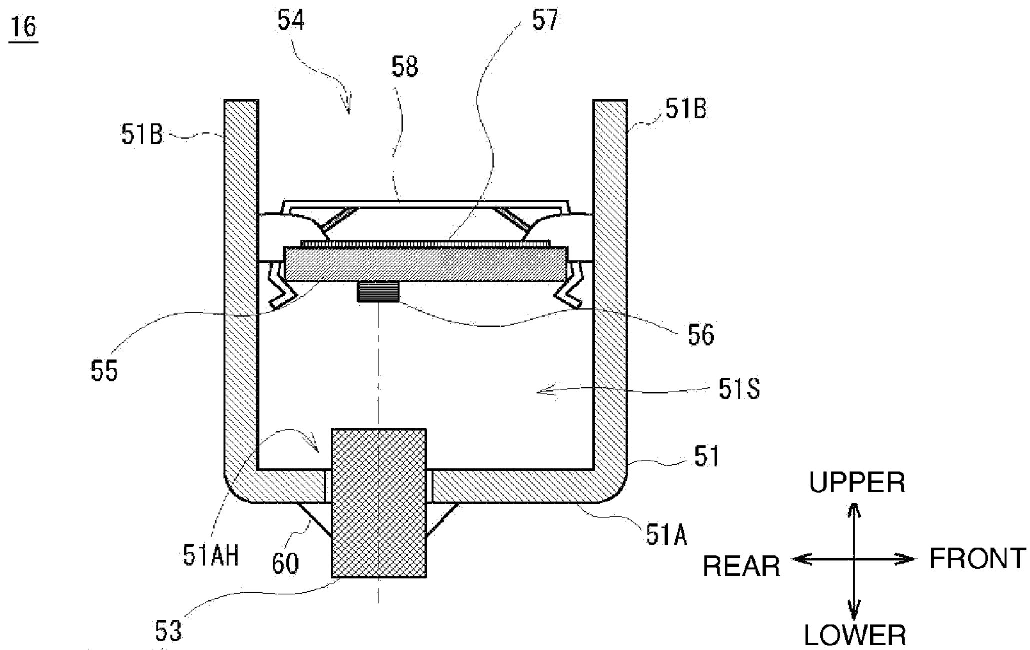

16
57
55E
51B
58
60
55

Fig. 7A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57
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51B
51B
55
56
51S
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51AH
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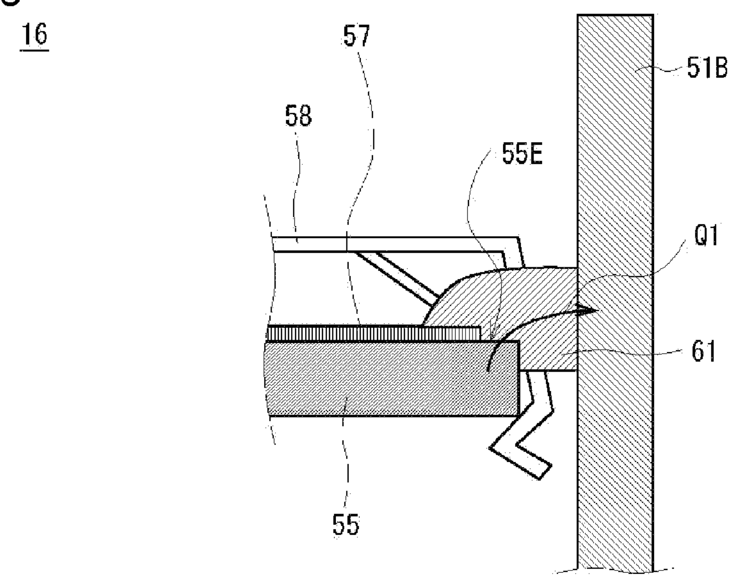
51A
53
UPPER
REAR
FRONT
LOWER

Fig. 7B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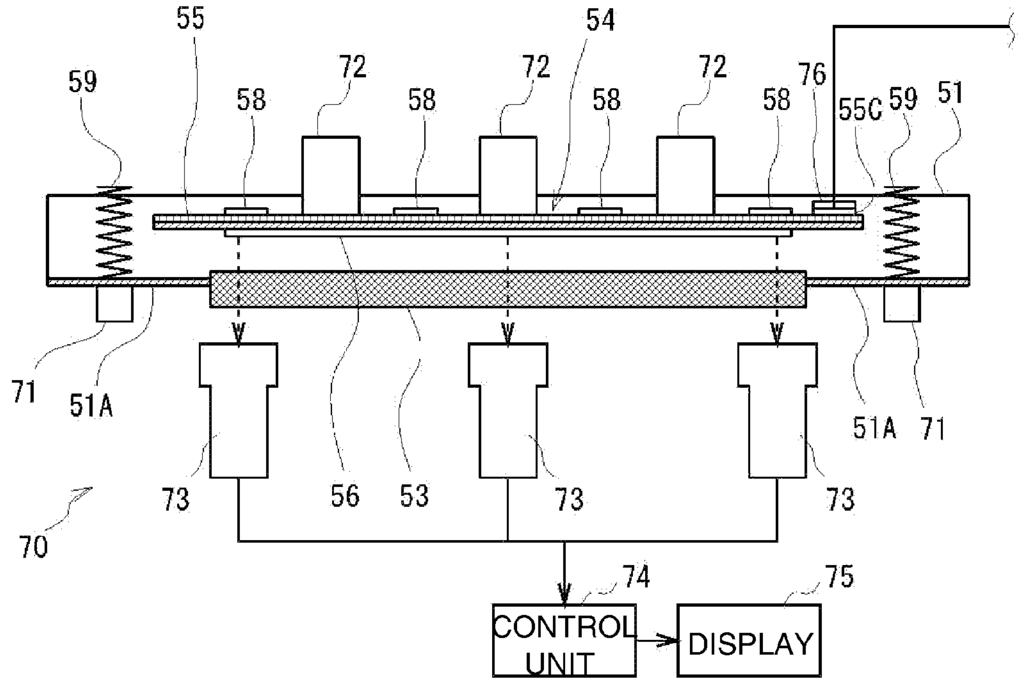
57
51B
58
55E
Q1
61
55

Fig. 8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54
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76
58
58
58
58
55C
59
51
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51A
51A
71
73
56
53
73
73
70
74
75
CONTROL UNIT
DISPLAY

Fig. 9A

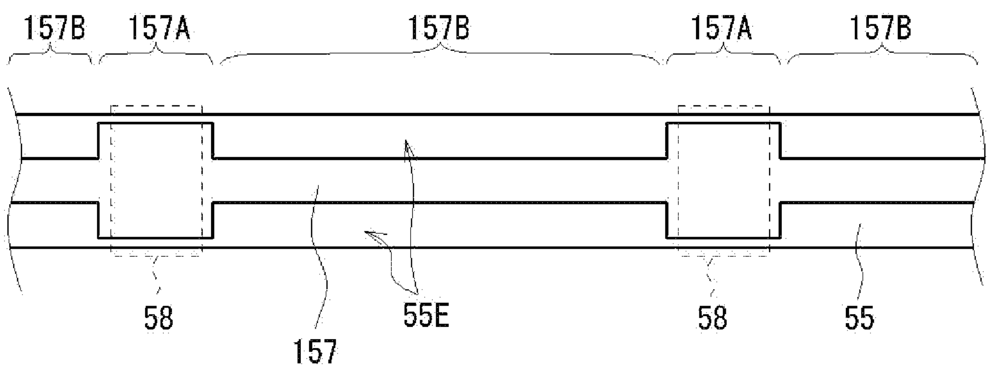
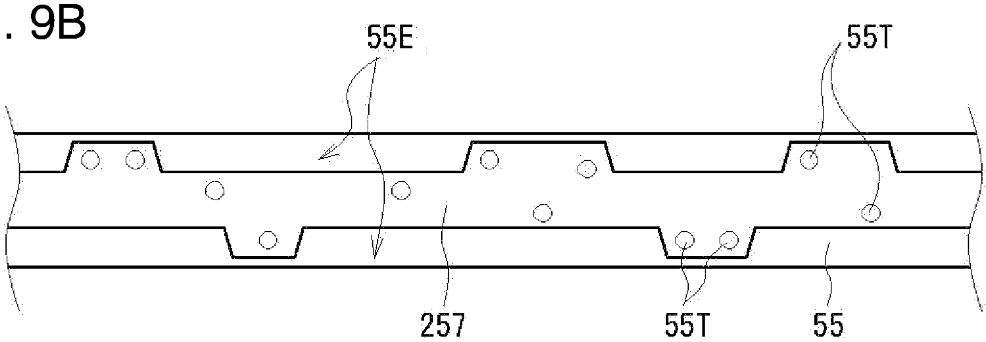


Fig. 9B



EXPOSURE DEVICE AND IMAGE FORMATION APPARATUS HAVING THERMALLY-CONDUCTIVE SEALANT

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority based on 35 USC 119 from prior Japanese Patent Application No. 2014-112869 filed on May 30, 2014, entitled "EXPOSURE DEVICE AND IMAGE FORMATION APPARATUS", the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This disclosure relates to an exposure device and an image formation apparatus, and is suitable for application to electrophotographic printers (hereinafter also referred to as printers), for example.

2. Description of Related Art

In widespread printers as conventional printers, an electrostatic latent image is formed on the surface of a photoconductive drum by irradiating the drum's surface with light from an exposure device such as an LED head, which includes light-emitting elements such as light emitting diodes (LEDs) and a lens array, and then is developed to a toner image with application of toner to the electrostatic latent image.

Some of such exposure devices include, for example, a substrate with one of its surfaces equipped with an LED array chip having LEDs arranged linearly, a rod lens array configured to condense light emitted from an LED array chip, and a holder holding the substrate and the rod lens array such that the LED array chip on the substrate and the rod lens array face each other. In addition, in some exposure devices, an attachment is attached to the substrate so as to cover the other surface opposed to the one surface, and the substrate is fixed to the holder by bonding the holder and the attachment (see Patent Literature 1, for example).

In such an exposure device, the LED array chip mounted on the substrate emits light in an irradiation pattern based on an image to be printed. The emitted light is converged through the rod lens array, and the surface of a photoconductive drum disposed at a focus position of the rod lens array is exposed to the light, so that an electrostatic latent image is formed on the surface.

[Patent Literature 1] Japanese Patent Application Publication No. 2012-66499 (FIG. 5)

SUMMARY OF THE INVENTION

In the manufacturing of such an exposure device, the substrate is fixed to the holder with an adhesive after the holder is positioned with the optical axis of the LED array chip aligned with the center of the rod lens array. For this reason, in the exposure device, the substrate needs to be formed slightly smaller than the holder in order to form a gap between them, and this gap remains after the bonding with the adhesive. In the exposure device, however, problems such as a reduction in the amount of light may arise if foreign matter such as toner enters a space at the one surface side of the substrate, namely, a space around the LED array chip and the rod lens array. To prevent this, the gap between the substrate and the holder is sealed with a sealant such as silicone.

Meanwhile, in some exposure devices, a protective sheet covering the entire other surface of the substrate is placed between the other surface of the substrate and the attachment. The protective sheet can prevent a circuit on the substrate from being physically damaged by the attachment and, particularly when the attachment is conductive like metal, can prevent a short circuiting of the circuit on the substrate if the sheet is insulative. In addition, by covering the entire other surface of the substrate with the protective sheet, the sheet can prevent foreign matter such as toner from entering the one surface side of the substrate via through-holes formed in the substrate.

On the other hand, due to its nature, the LED array chip of such an exposure device generates heat at the time of emitting light and transmits the heat to the substrate. However, since the substrate is not in contact with a thermally conductive component such as the holder and the other surface of the substrate is wholly covered with the protective sheet, the exposure device cannot release the generated heat to any other part efficiently. For this reason, the exposure device has a problem in that the LED array chip is heated to such an extremely high temperature as to degrade the performance of the chip, or even break the chip in some cases.

An embodiment of the invention aims to propose an exposure device and an image formation apparatus capable of securing a substrate position adjustment function and improving heat dissipation performance at the same time.

An aspect of the invention is an exposure device that includes: a substrate having a first and second surface opposed to each other, wherein a light-emitting element array is mounted on the first surface; a protective sheet covering the second surface while exposing a part of the second surface in the vicinity of an edge of the substrate to define an exposed part of the second surface; a holder that supports a condenser lens array and that supports the substrate, with a gap formed between the holder and the exposed part of the substrate, to position the substrate such that light emitted from the light-emitting element array is condensed on a predetermined irradiation location through the condenser lens array; and a thermally-conductive sealant that covers the exposed part of the second surface of the substrate and seals the gap.

According to the above aspect of the invention, the substrate can be positioned with respect to the holder so that the light emitted from the light-emitting element array attached to the substrate may be condensed appropriately through the condenser lens array. Further, thanks to the sealant that seals the gap between the substrate and the holder, it is possible to improve thermal conductivity between the holder and the exposed part defined in the second surface of the substrate.

Thus, the substrate can be positioned with respect to the holder while the position of the light-emitting element array is adjusted with respect to the condenser lens array. Further, thanks to the sealant that seals the gap between the substrate and the holder, it is possible to improve thermal conductivity between the holder and the exposed part defined in the second surface of the substrate. Thereby, this aspect of the invention can secure a substrate position adjustment function and improve heat dissipation performance at the same time.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view illustrating the configuration of a color printer.

FIG. **2** is a schematic view illustrating the configuration of an image drum unit.

FIG. **3** is a schematic view illustrating the configuration of an LED head.

FIG. **4** is a schematic perspective view illustrating the configuration of the LED head.

FIG. **5** is another schematic perspective view illustrating the configuration of the LED head.

FIGS. **6**A and **6**B are schematic sectional views illustrating the configuration of the LED head.

FIGS. **7**A and **7**B are other schematic sectional views illustrating the configuration of the LED head.

FIG. **8** is a schematic view illustrating the configuration of a manufacturing jig.

FIGS. **9**A and **9**B are schematic views illustrating the configuration of a protection sheet according to other embodiments.

DETAILED DESCRIPTION OF EMBODIMENTS

Descriptions are provided hereinbelow for embodiments based on the drawings. In the respective drawings referenced herein, the same constituents are designated by the same reference numerals and duplicate explanation concerning the same constituents is omitted. All of the drawings are provided to illustrate the respective examples only.

[1. Configuration of Color Printer]

As illustrated in a left side view of FIG. **1**, color printer **1** is a color electrophotographic printer, and is configured to print a desired color image on paper sheet P of A3 size or A4 size, for example.

Color printer **1** which is an image formation apparatus has various components arranged inside a substantially box-shaped printer chassis **2**. Incidentally, in the following description, a right-edge part in FIG. **1** is the front face of color printer **1**, and an upward/downward direction, a leftward/rightward direction, and a forward/rearward direction are used and are defined as color printer **1** is viewed while facing the front face of the printer.

Controller **3** has overall control of color printer **1**. Controller **3** is connected to a host apparatus (not illustrated) such as a personal computer by wire or wirelessly via a communication processor (not illustrated). Upon receiving a command to print a color image to be printed together with an image data of the color image from the host apparatus, controller **3** executes printing processing to form a print image on a surface of paper sheet P.

Sheet housing cassette **4**, sheet feeder **5**, and sheet-color measurement unit **6** are arranged inside printer chassis **2** in its lowermost part. Sheet housing cassette **4** is configured to house paper sheets P. Sheet feeder **5** is configured to pick up and feed one at a time paper sheets P stacked in sheet housing cassette **4**. Sheet-color measurement unit **6** is configured to measure the color of paper sheet P thus fed. Sheet feeder **5** is located at a front upper side of sheet housing cassette **4**, and includes rollers such as hopping roller **7** and paired register rollers **8**, a guide for guiding paper sheet P, and the like. Hopping roller **7** is disposed at the front upper side of sheet housing cassette **4** and has a central axis extending in the leftward/rightward direction, and paired register rollers **8** are disposed above hopping roller **7**.

Under the control of controller **3**, sheet feeder **5** rotates hopping roller **7**, paired register rollers **8**, and the like to pick up and take in one at a time paper sheets P housed in sheet housing cassette **4**, advance the sheet to a front upper part of the printer, and then flip it over toward the rear at a position substantially in the center in the upward/downward direction of printer chassis **2** and near the front edge thereof. Sheet-color measurement unit **6** measures the color of paper sheet P and sends the measurement result to controller **3**.

Transfer belt unit **10** is disposed inside printer chassis **2** above sheet housing cassette **4** in such a way as to traverse the inside of the entire printer chassis **2** in the forward/rearward direction. Transfer belt unit **10** includes: front and rear rollers **11** each having the shape of a slender cylinder and having a central axis extending in the leftward/rightward direction; and transfer belt **12** stretched around front and rear rollers **11**. Transfer belt **12** is in the form of an endless belt which is wide in the leftward/rightward direction, and travels along with the rotation of rollers **11**. Under control of controller **3**, transfer belt unit **10** rotates rollers **11** and thereby drives transfer belt **12** to transport paper sheet P transferred from sheet feeder **5** rearward on the upper surface of transfer belt **12**.

Meanwhile, above transfer belt unit **10**, i.e., in a part of printer chassis **2** higher than the center thereof, four image drum units **15**C, **15**M, **15**Y, and **15**K (hereinafter, these are referred to as image drum units **15** collectively) are arranged in that order from the rear side toward the front side. In other words, image drum units **15** of the respective colors are disposed in a so-called tandem arrangement.

Incidentally, image drum units **15**C, **15**M, **15**Y, and **15**K respectively correspond to the colors of cyan (C), magenta (M), yellow (Y), and black (K). In addition, image drum units **15**C, **15**M, **15**Y, and **15**K have the same configuration except for the colors of toner corresponding thereto. Image drum units **15** which are image formation units each have substantially the shape of a box relatively long in the leftward/rightward direction so as to suit to the horizontal width of paper sheet P.

Further, in printer chassis **2**, Light Emitting Diode (LED) heads **16**C, **16**M, **16**Y, and **16**K (hereinafter, these are referred to as LED heads **16** collectively) which are exposure devices are arranged to correspond to image drum units **15**C, **15**M, **15**Y, and **15**K respectively. LED heads **16** each have the shape of a rectangular solid long in the leftward/rightward direction. Each LED head **16** has LED elements inside which are arranged in the leftward/rightward direction, and is configured to cause the LED elements to emit light according to a light emission pattern based on image data fed by controller **3**. Image drum units **15** are located very close to LED heads **16** when mounted in printer chassis **2**, and are subjected to exposure processing by the light from LED heads **16**.

Further, image drum units **15**C, **15**M, **15**Y, and **15**K are respectively connected to toner cartridges **18**C, **18**M, **18**Y, and **18**K (hereinafter, these are referred to as toner cartridges **18** collectively) located above them. Toner cartridges **18** are each a hollow container long in the leftward/rightward direction which houses a powdery toner of the corresponding color and is incorporated with a predetermined stirring mechanism.

Incidentally, transfer rollers **13**C, **13**M, **13**Y, and **13**K (hereinafter, these are referred to as transfer rollers **13** collectively) are arranged in transfer belt unit **10** at four locations between front and rear rollers **11** and immediately below respective image drum units **15**. To put it another way, an upper part of transfer belt **12** is nipped between image drum units **15** and the corresponding transfer rollers **13**. Incidentally, each transfer roller **13** is designed to be capable of being charged.

Controller **3** causes toner to be fed from toner cartridges **18** to image drum units **15**. Controller **3** also causes each LED head **16** to emit light such that the light forms a light emission pattern according to image data fed by a host apparatus (not illustrated). In response to this, image drum units **15** form toner images according to the light emission patterns of their corresponding LED heads by using the toner fed by toner cartridges **18**, respectively, and transfer the toner images onto paper sheet P one by one (to be described in detail later). Thereby, the toner images of four colors according to the image data are sequentially transferred onto paper sheet P being transported by transfer belt unit **10**.

Fixation unit **20** is disposed behind transfer belt unit **10**, i.e., near the center in the upward/downward direction of printer chassis **2** and near the rear edge thereof. Fixation unit **20** includes heating roller **21** and pressure roller **22**. Heating roller **21** has the shape of a cylinder having a central axis extending in the leftward/rightward direction, and has a heater inside. Pressure roller **22** has the shape of a cylinder similarly to heating roller **21**, and presses its upper surface against the lower surface of heating roller **21** with a predetermined pressing force.

Fixation unit **20** is configured to heat heating roller **21** and rotate heating roller **21** and pressure roller **22** in their predetermined directions under the control of controller **3**. Thereby, fixation unit **20** applies heat and pressure onto paper sheet P, which is transferred from transfer belt unit **10**, i.e., on which the toner images of four colors are laid, so as to fix the toner to the sheet, and then transfers the sheet to a rear upper part of the printer.

Delivery unit **24** is disposed behind and above fixation unit **20**. Delivery unit **24** is formed by a combination of rollers (not illustrated) each having a central axis extending in the leftward/rightward direction, a guide for guiding paper sheet P, and the like. Under the control of controller **3**, delivery unit **24** rotates its rollers as needed to transport paper sheet P transferred from fixation unit **20** to the rear upper part of the printer, and then flip it over toward the front and discharge it to discharge tray **2**T formed on the upper surface of printer chassis **2**.

In this way, when executing a printing process, color printer **1** causes image drum units **15** of the respective colors to form toner images with light emitted by LED heads **16**, respectively, and sequentially transfers the toner images onto paper sheet P.

[2. Configuration of the Image Drum Unit]

Next, the configuration of each image drum unit **15** is described. As illustrated in the schematic sectional view of FIG. **2**, most of the outer periphery of image drum unit **15** is covered with frame **31**, and image drum unit **15** has a relatively large space inside.

Photoconductive drum **35** which is an electrostatic latent image carrier is disposed inside image drum unit **15** at a lower center thereof. Photoconductive drum **35** has the shape of a cylinder with a central axis extending in the leftward/rightward direction, and is supported by frame **31** to be rotatable about its central axis. Incidentally, photoconductive drum **35** is rotated in a direction denoted by arrow R**1** (R**1** direction) by a driving force transmitted from a motor not illustrated.

A relatively large region of a part, corresponding to the lower surface of photoconductive drum **35**, of frame **31** is left open. Thus, image drum unit **15** when mounted in printer chassis **2** (FIG. **1**) can bring the lower surface of photoconductive drum **35** into contact with transfer belt **12** or paper sheet P placed on transfer belt **12**. In addition, an exposure hole long in the leftward/rightward direction is bored in a part of frame **31** immediately above photoconductive drum **35**.

Charging roller **36** is disposed behind and above photoconductive drum **35**. Charging roller **36** has the shape of a cylinder having a diameter smaller than photoconductive drum **35**. Charging roller **36** is made of a semiconductive elastic material, for example, and has a circumferential side surface in contact with circumferential side surface **35**S of photoconductive drum **35**. Charging roller **36** is thereby configured to evenly charge a location of contact of circumferential side surface **35**S with this roller.

Development roller **38** is disposed ahead of and above photoconductive drum **35**. Development roller **38** has the shape of a cylinder having a diameter smaller than photoconductive drum **35**. Development roller **38** is made of semiconductive urethane rubber made by controlling, as needed, the electrical resistance of a urethane rubber material by adding thereto a conductive material such as carbon, for example, and is designed to be capable of being charged. The circumferential side surface of development roller **38** is in contact with circumferential side surface **35**S of photoconductive drum **35** on the rear side of the development roller, and is in contact with feed roller **39** on the front side thereof. Feed roller **39** has the shape of a cylinder having a diameter slightly smaller than development roller **38**, and is made of a semiconductive silicone foam sponge, for example.

Sheet-shaped development blade **40** is disposed ahead of and above development roller **38**. Development blade **40** is made of metal such as stainless steel or phosphor bronze, or a rubber material such as silicone rubber. The rear upper edge of development blade **40** is fixed to the inside of frame **31**, and a slight clearance is defined between the front lower edge of the blade and the circumferential side surface of development roller **38**.

Further, spacers **45** are arranged above and at both left and right sides of photoconductive drum **35**. The sizes of spacers **45**, their attachment positions with respect to frame **31**, and the like are so optimized that the distance between the circumferential side surface of photoconductive drum **35** and LED head **16** is set at a desired length by bringing the lower surface of LED head **16** into contact with the upper surfaces of the spacers (to be described in detail later).

For printing of an image on paper sheet P under the control of controller **3**, image drum unit **15** having the above configuration rotates photoconductive drum **35** in the R**1** direction, rotates charging roller **36**, development roller **38**, and feed roller **39** in a direction denoted by arrow R**2** (R**2** direction), and charges charging roller **36** and development roller **38**. Incidentally, image drum unit **15** causes photoconductive drum **35**, charging roller **36**, and development roller **38** to rotate without sliding over each other.

First, a rear upper part of circumferential side surface **35**S of photoconductive drum **35** is evenly charged by charging roller **36**, and then with the rotation of the drum in the R**1** direction, this charged part reaches the vicinity of the upper edge of the photoconductive drum and faces LED head **16**. With this event, circumferential side surface **35**S of photoconductive drum **35** is exposed to light emitted by LED head **16** in the light emission pattern based on image data, and thereby an electrostatic latent image according to the image data is formed on the drum.

On the other hand, by way of feed roller **39**, toner fed from toner cartridge **18** is attached to the circumferential side surface of development roller **38** which is rotated in the R**2** direction. Next, excess toner is shaved off the development roller by development blade **40**, so that toner is attached to the circumferential surface of the roller uniformly in the form of a thin film.

Photoconductive drum **35** is further rotated in the R**1** direction and, near the front edge of the drum where it comes into contact with development roller **38**, the toner formed in the form of a thin film on the circumferential side surface of development roller **38** is attached only to the part of circumferential side surface **35**S corresponding to the electrostatic latent image formed on the drum. In this manner, a toner image according to the image data is formed on circumferential side surface **35**S of photoconductive drum **35**. Incidentally, the toner image formed on circumferential side surface **35**S at this time is an image representing only one color component (that is, any of cyan, magenta, yellow, and black) that this image drum unit **15** handles.

Then, photoconductive drum **35** is further rotated in the R**1** direction, and thus the toner image reaches the vicinity of the lower edge of the drum. In this event, controller **3** causes transfer belt unit **10** (FIG. **1**) to transport paper sheet P to under image drum unit **15**, and charges transfer roller **13** with the polarity opposite to that of the toner. Accordingly, image drum unit **15** nips paper sheet P between charged transfer roller **13** and a part of photoconductive drum **35** where the toner image is formed, and transfers this toner image onto paper sheet P. Incidentally, if toner is left on circumferential side surface **35**S of photoconductive drum **35** after the toner image is transferred on paper sheet P, such toner is removed by a cleaning device not illustrated.

In this way, image drum unit **15** can form a toner image on circumferential side surface **35**S of photoconductive drum. **35** using the exposure function of LED head **16** while causing LED head **16** to face the vicinity of the drum.

3. Configuration of the LED Head

Next, the configuration of LED head **16** is described. As illustrated in FIGS. **3**, **4**, **5**, **6**, and **7**, LED head **16**, which is an exposure device, as a whole has the shape of a rectangular solid long in the leftward/rightward direction, and has a configuration where various components are attached to holder **51** which is a holder or a support member. Incidentally, FIG. **3** is a sectional view illustrating LED head **16** as well as photoconductive drum **35** as viewed from the front side. FIG. **4** is a perspective view illustrating LED head **16** as viewed from the obliquely-left front upper side. FIG. **5** is an enlarged perspective view illustrating a part of FIG. **4** on an enlarged scale. FIG. **6**A is a sectional view taken along line A**1**-A**2** of FIG. **3** and FIG. **6**B is a partial enlarged view of FIG. **6**A. FIG. **7**A is a sectional view taken along line B**1**-B**2** of FIG. **3** and FIG. **7**B is a partial enlarged view of FIG. **7**A.

Holder **51** has, as its central part, basal part **51**A in the form of a plate long in the leftward/rightward direction and thin in the upward/downward direction. Side parts **51**B in the form of a plate long in the leftward/rightward direction and thin in the forward/rearward direction extend upward from both front and rear sides of basal part **51**A. Hole part **51**AH in the form of a slit long in the leftward/rightward direction is bored at substantially the center of basal part **51**A in the forward/rearward direction such that it penetrates basal part **51**A in the upward/downward direction. Side parts **51**B each have the shape of a substantially flat plate without any steps or the like. In addition, light shield plates **52** stand upward on the upper surface of basal part **51**A and at both left and right sides of hole part **51**AH Incidentally, holder **51** is manufactured by subjecting a steel sheet in the form of a flat plate to a cutting process, bending process, and the like, and its manufacturing cost is relatively low.

Rod lens array **53** which is a condenser lens array is mounted in hole part **51**AH. Rod lens array **53** as a whole has them shape of a rectangular solid long in the leftward/rightward direction, and has multiple minute lenses arrayed in the leftward/rightward direction. These lenses have such an optical characteristic as to converge light emitted from LED array chip **56** to be described later.

In addition, LED substrate unit **54** is mounted in holder **51** above rod lens array **53** such that it is sandwiched between front and rear side parts **51**B. LED substrate unit **54** includes substrate **55**, LED array chip **56**, protective sheet **57**, and attachments **58**.

Substrate **55** is made of a so-called glass epoxy substrate and has the shape of a plate long in the leftward/rightward direction and thin in the upward/downward direction. Substrate **55** has such a configuration that wiring layers each having a predetermined wiring pattern formed thereon are stacked in the upward/downward direction. The length in the forward/rearward direction of substrate **55** is shorter than the distance between side parts **51**B of holder **51**, and the length in the leftward/rightward direction thereof is shorter than the distance between light shield plates **52** of holder **51**.

Incidentally, a part of the wiring pattern is exposed on each of the upper and lower surfaces of substrate **55**, and through holes for connecting the wiring patterns of the layers to each other in a vertical direction are provided at appropriate locations in substrate **55**. Moreover, connector **55**C for connecting a wiring member is attached to a predetermined position on the upper surface of substrate **55**.

LED array chip **56** which is a light-emitting element array is attached to the lower surface of substrate **55**. In LED array chip **56**, light-emitting points at which the elements emit light downward are arrayed in the leftward/rightward direction at predetermined minute intervals. LED array chip **56** is physically fixed, through die bonding for example, and electrically connected to the wiring pattern formed on the lower surface of substrate **55**.

Protective sheet **57** is made of an insulating material. Protective sheet **57** has the shape of a film which is thin in the upward/downward direction and long in the leftward/rightward direction, and which has a length in the forward/rearward direction (i.e., width) narrower than substrate **55**. In addition, holes, notches, and the like are formed in protective sheet **57** as needed so that connector **55**C and the like may be exposed on the sheet without being covered therewith. Protective sheet **57** is laid over the upper surface of substrate **55**, namely, over the surface opposite to the lower surface on which LED array chip **56** is mounted, in such a way that both front and rear edges of protective sheet **57** are respectively spaced from both front and rear edges of substrate **55** in the forward/rearward direction.

Attachments **58** which are attachment members are each formed by subjecting a thin steel sheet as thin as about 0.1 to 0.3 [mm] to a cutting process and a bending process, for example. Attachment **58** is conductive due to the nature of a steel sheet, and can exert elastic force upon the application of an external force such as a bending force. With such an elastic force, attachment **58** can attach protective sheet **57** to substrate **55** while pinching the sheet between the attachment and the substrate, as illustrated in FIGS. **6** and **7**. Incidentally, because attachment **58** is made of a steel sheet, it can stably keep its shape and elastic force even under a high temperature environment, unlike a resin material or the like.

Further, coil springs **59** are attached to the upper surface of basal part **51**A to stand upward near both left and right edges of holder **51**. When compressed in the upward/downward direction, coil springs **59** exert an elastic force to try to extend in the upward/downward direction. When coil springs **59** at their upper ends are fixed to the printer chassis

(FIG. **1**) side while being compressed in the upward/downward direction, they press the lower surface of basal part **51**A of holder **51** against spacers **45** (FIG. **3**) on the image drum unit **15** side. Thereby, coil springs **59** can adjust the distance between the circumferential side surface of photoconductive drum **35** and the lower edge of rod lens array **53** to a desired distance and keep this desired distance.

In this way, LED substrate unit **54** of LED head **16** is fixed to holder **51** in the state where protective sheet **57** is laid over the upper surface of substrate **55** at an appropriate position and attachments **58** are attached thereto.

[4. Process of Manufacturing the LED Head]

Next, a process of manufacturing LED head **16** is described mainly in terms of a process of manufacturing LED substrate unit **54** and a process of mounting LED substrate unit **54** in holder **51**.

In a process of assembling LED substrate unit **54**, firstly, LED array chip **56** is attached to the lower surface of substrate **55**, and then protective sheet **57** is laid over the upper surface of substrate **55**. In this event, the position of protective sheet **57** with respect to substrate **55** is appropriately set by using a jig (not illustrated). Thereby, as illustrated in FIGS. **4**, **5**, **6**, and the like, both front and rear edges of protective sheet **57** are positioned inward of both front and rear edges of substrate **55** so that exposed parts **55**E, being front and rear circumferential portions of substrate **55** on its upper surface, may be exposed.

Subsequently, in LED substrate unit **54** in a part above substrate **55** where protective sheet **57** is laid over the substrate, attachment **58** is elastically deformed by application of external force to widen the distance between the two edges of attachment **58** in the forward/rearward direction. While its deformed shape is kept, attachment **58** is moved downward and then released from the external force. Thereby, while securing the insulation properties of the upper surface of substrate **55** and protecting the upper surface thereof against physical damage by use of protective sheet **57**, LED substrate unit **54** can fix the position of protective sheet **57** by use of attachment **58**.

Incidentally, as illustrated in FIGS. **3** and **4**, multiple attachments **58** are mounted in LED substrate unit **54** such that they are arranged at almost predetermined intervals in the leftward/rightward direction, i.e., in the direction in which the light-emitting points of LED array chip **56** are arrayed.

Next, in LED head **16**, LED substrate unit **54** is mounted in holder **51** by using manufacturing jig **70** illustrated in FIG. **8**. Manufacturing jig **70** includes: spacers **71** arranged one by one at the lower side of the head and near both left and right edges thereof; chucks **72** arranged at the upper side of the head; photosensors **73** arranged at the lower side of the head; controller **74**; display **75**; and jig connector **76**.

Spacers **71** correspond to spacers **45** (FIG. **3**) of image drum unit **15**. The position of LED head **16** in manufacturing jig **70** is set by bringing the lower surface of basal part **51**A of holder **51** into contact with the upper surfaces of spacers **71**. Chucks **72** have a suction function, and are capable of sucking up the upper surface of LED substrate unit **54** and holding the substrate part. In addition, chucks **72** are configured to be capable of moving in the upward/downward direction or in the leftward/rightward direction, adjusting their angles, and the like while holding LED substrate unit **54**.

Photosensors **73** are equivalent to photosensitive drum **35**. Photosensors **73** each have photosensing elements for receiving light on its upper surface, and the distance between the upper surfaces of spacers **71** and the upper surface of photosensor **73** is adjusted appropriately. Photosensor **73** is configured to receive light incident thereon from the above, generate a light reception signal according to the amount of received light, and send it to controller **74**. Controller **74** is configured to form a predetermined display screen by using figures, graphs, and the like based on the received light reception signal, and display it on display **75** to notify an operator and the like of the amount of receiving light.

Jig connector **76** is attached to the leading end of a wiring member electrically connected to controller **74**, and includes terminals (not illustrated), and is formed in such a shape as to be able to be engaged with connector **55**C of substrate **55**. Jig connector **76** can supply LED array chip **56** of LED substrate unit **54** with electrical signals for causing the LED elements to emit light by connecting jig connector **76** to connector **55**C of substrate **55** and bringing their terminals into continuity with each other.

For manufacturing LED head **16**, firstly, rod lens array **53** and two coil springs **59** are attached to holder **51**. Incidentally, a sufficient amount of adhesive **60** is used to bond rod lens array **53** to holder **51** so as to close the gap between holder **51** and rod lens array **53**, or predetermined filler is filled between the gap therebetween.

Next, holder **51** is mounted to manufacturing jig **70** in the state where coil springs **59** are compressed in the upward/downward direction. Here, coil springs **59** exert an elastic force while their upper ends are in contact with predetermined positions of manufacturing jig **70**. Coil springs **59** thereby apply a downward force on holder **51** to press the lower surface of basal part **51**A against the upper surfaces of spacers **71** and bring them into contact with each other without any gap between them. Since the distance between the upper surfaces of spacers **71** and the upper surfaces of photosensors **73** is set appropriately, manufacturing jig **70** can fix holder **51** at an appropriate position temporarily.

Next, manufacturing jig **70** adsorbs LED substrate unit **54** in the state where chucks **72** are moved above holder **51**. In addition, jig connector **76** of manufacturing jig **70** is connected to connector **55**C of substrate **55** in LED substrate unit **54**.

In the above state, by manipulation by an operator, manufacturing jig **70** moves chucks **72** downward to roughly align the position of LED substrate unit **54** with an ideal mounting position in holder **51** first. Then, manufacturing jig **70** supplies a predetermined signal to LED array chip **56** of LED substrate unit **54** through jig connector **76** so as to cause the elements of LED array chip **56** to emit light. The light outputted from LED array chip **56** as diverging rays at this time is converged by rod lens array **53** and irradiated on the upper surfaces of photosensors **73**.

Manufacturing jig **70** lets an operator and the like visually check through display **75** the amount of light received by photosensors **73**. At this time, with reference to the amount of receiving light, the operator finely adjusts the positions and angles of chucks **72** holding LED substrate unit **54** so that the position of LED substrate unit **54** may be adjusted to an optimal position, that is, a position where the sensors can receive a desired amount of light. Thereby, LED substrate unit **54** can cause the optical axis of LED array chip **56** to be directed in parallel with the central axis of rod lens array **53**, and can set the distance between the lower edge of LED array chip **56** and the upper edge of rod lens array **53** at an ideal distance throughout a main-scanning direction (i.e., the leftward/rightward direction).

In the above state, LED substrate unit **54** is fixed to the ideal position with respect to holder **51** by filling adhesive **60** (FIG. **6**) in front and rear side portions of each attachment

58 and between front and rear side parts 51B of holder 51. Adhesive 60 is, for example, an ultraviolet cure adhesive designed to be cured in a relatively short period of time when applied to a location to be bonded in the form of liquid or gel and then irradiated with ultraviolet light.

Next, in LED head 16, sealant 61 made of silicone is filled in gaps between LED substrate unit 54 and front and rear side parts 51B of holder 51 so as to fill in these gaps (FIGS. 7A and 7B). Thereby, LED head 16 can substantially seal space 51S which is surrounded by basal part 51A and front rear side parts 51B of holder 51 and the lower surface of substrate 55.

At this time, sealant 61 is filled to come into contact with both side parts 51B of holder 51 and parts of the upper surface of substrate 55 that are exposed without being covered with protective sheet 57, namely, parts around the front and rear edges of substrate 55 (these are referred to as exposed parts 55E in this disclosure).

Due to the nature of silicone, sealant 61 is made relatively soft and has a thermal conductivity higher than the material for protective sheet 57. Thus, once filled, sealant 61 is deformed flexibly to substantially seal the gaps between substrate 55 and holder 51 and come into contact with a relatively large area of each of exposed parts 55E and side parts 51B.

Thereby, as illustrated by arrow Q1 in FIG. 7B, sealant 61 can effectively transmit the heat of substrate 55 to holder 51. Moreover, because sealant 61 is flexible but as rigid and strong as gel, it can keep well its shape at the time of being filled without flowing off like a liquid.

Incidentally, LED head 16 is designed to prevent an incident of external light coming in from the leftward/rightward direction, the entrance of foreign matter, and the like by using left and right light shield plates 52 of holder 51 (FIG. 3).

In this way, in LED head 16, exposed parts 55E not covered with protective sheet 57 are defined in the upper surface of substrate 55. Then, in the process of mounting LED substrate unit 54, sealant 61 seals the gaps between substrate 55 and side parts 51B of holder 51, and is widely brought into contact with exposed parts 55E and side parts 51B.

Incidentally, in LED head 16, if LED substrate unit 54 should be displaced from its ideal position with respect to holder 51 after manufacturing, sealant 61 is removed and attachments 58 of a relatively low cost are cut off and broken with a nipper or the like. Thereby, according to LED head 16, it is possible to take out substrate 55 and LED array chip 56 of relatively high cost from holder 51 without damaging these, and reuse and mount these to new holder 51 or reused holder 51.

[5. Operation and Effect]

In the manufacturing of LED head 16 of color printer 1 according to this embodiment with the above configuration, LED substrate unit 54 is formed by laying protective sheet 57 over the upper surface of substrate 55, on which LED array chip 56 is mounted, so that exposed parts 55E (FIGS. 5, 6, and 7) may be defined therein, and attaching attachments 58.

Next, in LED head 16, the position of LED substrate unit 54 is adjusted with respect to holder 51, in which rod lens array 53 is mounted, by use of manufacturing jig 70. In this adjusted state, attachments 58 are fixedly attached with adhesive 60, and the gaps between substrate 55 and holder 51 are sealed with sealant 61.

Thus, according to LED head 16, it is possible to position LED substrate unit 54 so that photosensors 73 can receive an optimal amount of light emitted from LED array chip 56 and converged by rod lens array 53. Accordingly, when installed in printer chassis 2, LED head 16 can irradiate circumferential side surface 35S of photoconductive drum 35 (FIG. 2) with an optimal amount of light outputted from LED array chip 56 and appropriately converged through rod lens array 53.

In addition, at this time, LED substrate unit 54 can prevent electrical contact (i.e., electrical continuity) between attachments 58 and the upper surface of substrate 55 with protective sheet 57, and prevent minute foreign matter such as toner from entering space 51S through the through-holes formed in substrate 55.

Further, because sealant 61 to seal the gaps between substrate 55 and holder 51 is in contact with a large area of each of exposed parts 55E on the upper surface of substrate 55 and side parts 51B of holder 51, LED head 16 can effectively transmit heat between substrate 55 and holder 51.

Thereby, LED head 16 can transmit heat generated by the emission of light by LED array chip 56 to substrate 55, then smoothly transmit the heat from exposed parts 55E of substrate 55 to side parts 51B of holder 51 via sealant 61, and then diffuse the heat from the outer circumferential surface of holder 51 toward a surrounding space. In other words, LED head 16 can transmit heat generated by the emission of light by LED array chip 56 to holder 51 effectively without confining the heat inside substrate 55 or space 51S (FIG. 7), and thus can prevent deterioration in the performance (such as light-emission efficiency) of LED array chip 56, reduction in the life of the chip, damage on the chip, and the like due to the heat.

Further, LED head 16 can increase transmission efficiency of heat from substrate 55 to holder 51 while using sealant 61 made of silicone as in the conventional case, only by putting a twist on the shape of protective sheet 57 so that exposed parts 55E may be defined in the upper surface of substrate 55. In other words, it is possible to manufacture LED head 16 at the same cost as a conventional LED head because there is no need to add a member for transmitting heat from substrate 55 to holder 51 to an LED head with a conventional configuration, nor use a sealant and the like of a nature different from that of a conventional LED head.

To put it another way, sealant 61 made of silicone having moderate flexibility and insulation properties is conventionally used for the purpose of filling the gaps between substrate 55 and holder 51 originally, that is, while no attention is paid to its thermal conductivity. Against such a background, while paying attention to the fact that silicone has good thermal conductivity, the embodiment forms exposed parts 55E in substrate 55 and uses sealant 61 also as a thermal conductor in LED head 16. The embodiment can thereby improve the heat dissipation property drastically while keeping the cost the same as before.

Further, even if through-holes should be formed in exposed parts 55E of substrate 55, LED head 16 can prevent foreign matter from dropping in space 51S through the through-holes thanks to sealant 61 covering the upper surfaces of these parts. Furthermore, owing to its moderate rigidity, sealant 61 can keep covering the gaps between substrate 55 and holder 51 and exposed parts 55E without flowing off to space 51S through the through-holes.

According to the configuration described so far, in LED head 16 of color printer 1, LED substrate unit 54 is formed by laying protective sheet 57 over the upper surface of substrate 55, on which LED array chip 56 is mounted, so that exposed parts **55**E may be defined therein, and attaching attachments **58**. Then, in the state where the position of LED array chip **56** is adjusted with respect to rod lens array **53** of holder **51**, LED substrate unit **54** is bonded to side parts **51**B of holder **51** with adhesive **60**. Then, the gaps between substrate **55** and holder **51** are sealed with sealant **61**. Thereby, LED head **16** can improve thermal conductivity between exposed parts **55**E and side parts **51**B, and transmit and dissipate heat, generated in LED array chip **56** and transmitted to substrate **55**, via exposed parts **55**E and sealant **61**.

[6. Other Embodiments]

Note that what is described in the above embodiment is a case where protective sheet **57** is rectangular in shape. However, the invention is not limited thereto. For example, the width in the forward/rearward direction of protective sheet **57** may be enlarged only at locations where attachments **58** are mounted and reduced at parts other than these locations, as illustrated in FIG. **9**A. Thereby, it is possible to prevent unnecessary continuity or short circuiting of substrate **55** due to attachments **58**, and increase the area of exposed parts **55**E to further improve thermal conductivity between substrate **55** and sealant **61**.

Alternatively, for example, protective sheet **57** may have such a shape as to match locations where through-holes **55**T are formed on the upper surface of substrate **55**, that is, such a shape as to positively cover through-holes **55**T and positively expose other parts, as illustrated in FIG. **9**B. In this case, even if there should be an error in the filling of sealant **61**, it is possible to avoid such a risk that foreign matter drops in space **51**S through exposed through-holes **55**T.

Further, what is described in the above embodiment is a case where attachments **58** are made of a thin steel sheet which is conductive. However, the invention is not limited thereto. For example, attachments **58** may be made of a non-conductive material such as a resin material. In this case, protective sheet **57** can prevent substrate **55** from being damaged by the contact of attachments **58**.

Further, what is described in the above embodiment is a case where sealant **61** is conductive. However, the invention is not limited thereto. For example, if an insulating material is applied on the upper surface of substrate **55**, sealant **61** may be made of a non-insulating material. In this case, protective sheet **57** may also be made of a non-insulating material as long as it is capable of physically protecting the upper surface of substrate **55**. In sum, any sealant **61** can do as long as it never interferes with the electrical operation of substrate **55** and it can conduct heat from exposure parts **55**E of substrate **55** to side parts **51**B of holder **51** highly efficiently.

Further, what is described in the above embodiment is a case where attachments **58** are bonded to side parts **51**B of holder **51** when LED substrate unit **54** is mounted in holder **51**. However, the invention is not limited thereto. For example, substrate **55** may be directly bonded to side parts **51**B of holder **51**. Alternatively, LED substrate unit **54** may be mounted in holder **51** by engaging side parts **51**B with an engaging body of a predetermined shape formed in each attachment **58**.

Further, what is described in the above embodiment is a case where the invention is applied to LED heads **16** of the respective color for image drum units **15** of the respective color which are arranged in series in the forward/rearward direction in tandem type color printer **1**. However, the invention is not limited thereto. For example, the invention may be applied to LED heads mounted in other type color printers such as a four-cycle type color printer.

Further, what is described in the above embodiment is a case where four LED heads **16** corresponding to the colors of yellow, magenta, cyan, and black are mounted in printer chassis **2** of color printer **1** for color printing. However, the invention is not limited thereto. For example, three or less LED heads **16** or five or more LED heads **16** may be mounted in printer chassis **2** according to the number of colors of toner to be used in a color printer. Alternatively, one LED head **16** may be mounted in a monochrome printer for monochrome printing.

Further, in the above embodiment, the invention is applied to color printer **1** as an image formation apparatus. However, while not limited thereto, the invention is applicable to apparatuses such as a facsimile machine, a multi function product (MFP), and a copier as long as they have LED head **16** as an exposure device as in the case of color printer **1**.

Further, the invention is not limited to the embodiment and other embodiments described above. In other words, the invention is applicable to an embodiment in which a part of, or all of, the embodiment and other embodiments described above are used in combination, or an embodiment in which a part of these embodiments is extracted.

Further, what is described in the above embodiment is a case where color printer **1** as an image formation apparatus includes LED head **16** as an exposure device including substrate **55** as a substrate, protective sheet **57** as a protective sheet, attachment **58** as an attachment member, holder **51** as a holder, and sealant **61** as a sealant. However, the invention is not limited thereto. An image formation apparatus may include an exposure device including a substrate, a protective sheet, an attachment member, a holder, and a sealant of other various configurations.

The invention is usable in a wide range of apparatuses including color printers and copiers which use light from one or more LEDs for exposure.

The invention claimed is:

1. An exposure device comprising:

a substrate having a wiring pattern of a wiring member therein and having a first surface and a second surface opposed to the first surface, wherein a light-emitting element array for emitting exposure light is mounted on the first surface;

a protective sheet covering the second surface while leaving at least a part of the second surface exposed in the vicinity of an edge of the substrate to define an exposed part of the second surface;

an attachment member attached to the substrate and pressing the protective sheet to the second surface to thereby fix the protective sheet to the second surface;

a holder that supports a condenser lens array for condensing light, and that supports the attachment member to support the substrate via the attachment member, with a gap formed between the holder and the exposed part of the substrate, to position the substrate such that light emitted from the light-emitting element array is condensed on a predetermined irradiation location through the condenser lens array; and

a thermally-conductive sealant that covers the exposed part of the second surface of the substrate and seals the gap such that the thermally-conductive sealant is in direct contact with both the exposed part and the holder.

2. The exposure device according to claim **1**, wherein

the substrate exposes a part of the wiring member on the second surface,

the attachment member is conductive, and

the protective sheet is insulative.

3. The exposure device according to claim **2**, wherein
the substrate exposes a part of the wiring member on the exposed part of the second surface, and
the sealant is insulative.

4. The exposure device according to claim **1**, wherein
the protective sheet is shaped to define the exposed part of the second surface of the substrate such that a width of the exposed part from the edge of the substrate is greater at a portion away from a location of contact of the protective sheet with the attachment member than at a portion near the location of the contact.

5. The exposure device according to claim **1**, wherein
the substrate is provided with a through-hole, and
the protective sheet is insulative and formed in such a shape as to cover the through-hole.

6. The exposure device according to claim **1**, wherein
the substrate is provided with through-holes, and
the sealant is insulative and covers a through-hole formed in the exposure part of the second surface of the substrate.

7. An image formation apparatus comprising the exposure device according to claim **1**.

8. The exposure device according to claim **1**, wherein
the exposed part is provided at each widthwise side of a protection area of the second surface which is covered with the protective sheet,
the thermally-conductive sealant is provided to cover the exposed part at the each widthwise side of the protection area.

9. The exposure device according to claim **1**, further comprising
a glue provided in the gap between the substrate and the holder and fixing the attachment to the holder, thereby fixing the substrate to the holder via the attachment, wherein
the thermally-conductive sealant seals an area of the gap where the glue have not sealed the gap.

10. A method of manufacturing an exposure device having a substrate having a first surface and a second surface opposed to the first surface, wherein a light-emitting element array for emitting exposure light is mounted on the first surface, the method comprising:
covering the second surface with a protective sheet such except for a part of the second surface in the vicinity of an edge of the substrate, which is defined as an exposed part of the second surface;
attaching an attachment member to the substrate such that the attachment member presses and fixes the protective sheet to the second surface of the substrate;
fixing the attachment member to a holder having a condenser lens array supported, with a gap formed between the holder and the exposed part of the second surface of the substrate, while positioning the substrate such that light emitted from the light-emitting element array is condensed on a predetermined irradiation location through the condenser lens array; and
providing a thermally-conductive sealant such that the sealant covers the exposed part of the second surface of the substrate and seals the gap and thereby the thermally-conductive sealant is in direct contact with both the exposed part and the holder.

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